Cereal cultivation at Swifterbant?

Cappers, R. T. J.; Raemaekers, D. C. M.

Published in:
Current Anthropology

DOI:
10.1086/588494

Cereal Cultivation at Swifterbant?

Neolithic Wetland Farming on the North European Plain

by R. T. J. Cappers and D. C. M. Raemaekers

The transition to early agriculture on the North European Plain is a much debated issue in which emphasis is placed on the available pollen evidence. It has been suggested that cereal cultivation was probably practiced in the upland areas and surplus yields were brought to the wetland sites. An alternative model that gives special attention to crop assemblages, flooding, and yields and is illustrated with evidence from the type-location sites of Swifterbant, dated between 4300 and 4000 BC, envisions cereal cultivation in the wetlands themselves. Evidence for early agriculture is found in particular in pollen diagrams, diatom analysis, and large numbers of cereal remains. It appears that small-scale cereal cultivation may have been possible and attractive in addition to hunting and gathering in wetland sites because of their variety of biotopes, including areas suitable for agriculture.

The date of the beginning of cereal cultivation in Britain, northern Germany, and southern Scandinavia is heavily debated on the basis of pollen diagrams. Until the 1950s, prehistoric occupation of the massive wetland area in the western part of the Netherlands was generally seen as impossible (Van Gijn and Louwe Kooijmans 2005, 214). Since then new finds have led to the conclusion that the area was indeed inhabited, and the question has become how the wetland occupation should be interpreted. This question has been of great importance for Neolithic archaeology because sites in the sandy uplands are little known and poorly preserved. The data set for this period therefore consists of well-preserved wetland sites and flint scatters in the drier cover-sand uplands, and the question arises how representative the wetland data are for the subsistence base in the uplands (Louwe Kooijmans 1993; Raemaekers 1999).

The central problem is that we find cereal remains in wetland environments which from our modern perspective are far from ideal for cereal cultivation. As Van Zeist and Palfenier-Vegter (1981, 143), referring to the archaeobotanical remains from Swifterbant S3, put it,

> The barley and wheat grains from Swifterbant do not in themselves necessarily imply that these cereals were grown locally. In view of the local situation, with only very little potential arable land, one may wonder whether crop plants were actually grown there. One could imagine that the crops had been grown elsewhere, on the higher soils of the Land van Vollenhove, the Veluwe or the coastal dune area, and that the people who spent a part of the year at Swifterbant had brought the grains with them.

The general idea has been that cereal cultivation was less important at these wetland sites than in the uplands (Bakels 1986, 1991; Louwe Kooijmans 1987, 2005; Gehasse 1995). The question is whether it is possible to break free from this perspective and somehow interpret the available data from the perspective of the prehistoric communities. In this study it is hypothesized that agriculture can be practiced on a small scale in a wetland environment at low risk. The reevaluation of the evidence for local cereal cultivation on the wetland sites of the Swifterbant culture is of crucial importance for understanding the representativeness of wetland sites in general. The results of study of these sites produce new insight into the functional relations between wetland and upland communities and the character of both wetland and upland subsistence strategies.

The Late Mesolithic and Neolithic Swifterbant culture occupied the wetlands between Antwerp (Belgium) and Hamburg (Germany) from ca. 5000 BC (start of pottery production in the Swifterbant style) until ca. 3400 BC, when it was replaced by the Vlaardingen group in the south and the Funnel Beaker culture in the north. Occupation remains from this period are virtually absent from the cover-sand area between the loess area of Central Europe and the wetlands, and therefore it remains unclear to what extent people of the Swifterbant culture occupied that area. The introduction of small numbers of domestic animals around 4700 BC marks the beginning of the Neolithic in the region, and the earliest

R. T. J. Cappers is Professor of Ecology and Paleoecology of the Near East at the Groningen Institute of Archaeology, University of Groningen (Poststraat 6, 9712 ER Groningen, the Netherlands [r.t.j.cappers@rug.nl]), and at Leiden University. **D. C. M. Raemaekers** is Professor of Prehistoric Archaeology at the institute. This paper was submitted 12 I 06 and accepted 5 X 07.

 0011-3204/2008/4903-0003$10.00. DOI: 10.1086/588494

finds of cereals in Swifterbant contexts date to around 4300–4000 BC (Louwe Kooijmans 2001, fig. 14.10; Raemaekers 1999).

Analysis of the Available Evidence

Five sites of the Swifterbant culture have produced evidence of agriculture (fig. 1). The first is the river dune site Hazendonk, where layers 1 and 2 are attributed to the Swifterbant culture and dated between 4000 and 3800 BC (Louwe Kooijmans 1976; Raemaekers 1999). One pollen diagram has been published (Louwe Kooijmans 1974, fig. 39), and Bakels (1981; 1986, 5) reports that cereal pollen were found in the spectra related to the occupation phases and interprets this as evidence of threshing.

The second is the river dune site Urk-E4. Unfortunately, the botanical evidence here cannot be dated precisely because clear stratigraphy is lacking. A series of linear soil traces with a depth of a few centimeters, a width of 2–8 centimeters, and a length of up to several meters was studied using thin sections and pollen analysis in order to determine whether they might be interpreted as plough marks. The thin-section analysis suggested that the surface had been cleared of vegetation using fire and the resulting charcoal mixed with the sand as a result of repeated human interference (Exaltus, cited in Peters and Peeters 2001). The pollen analysis revealed the presence of

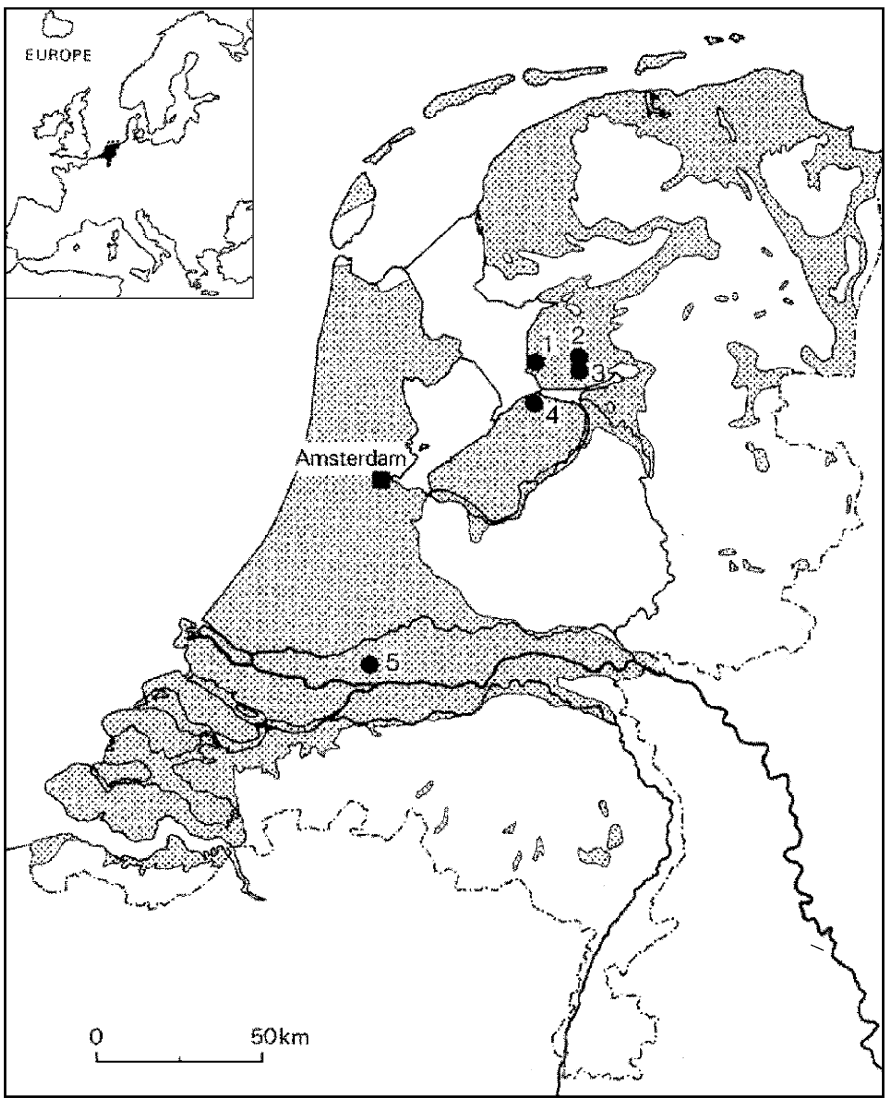

Figure 1. The Netherlands and sites mentioned in text. *1,* Urk-E4; *2,* P14; *3,* Schokkerhaven; *4,* Swifterbant; 5, Hazendonk.

wheat pollen (*Triticum*) and pollen from ruderal and grassland plants. Both types of analysis might be advanced as arguments for an interpretation of these traces as plough marks (Van Smeerdijk, cited in Peters and Peeters 2001).

The third site is P14. The botanical remains from this site, on a boulder clay outcrop, cannot be dated more precisely than to the Swifterbant culture. In addition to the macro remains discussed below, there are pollen diagrams with low numbers of cereal pollen, and local cereal cultivation cannot be ruled out (Gehasse 1995, 60–61).

The fourth site is the Late Swifterbant river dune site of Schokkerhaven. Although the evidence is minimal, it has yielded kernels of naked barley and emmer wheat (Gehasse 1995, 70).

The last and most important sites for our reassessment of wetland agriculture are the type-location sites of Swifterbant. They are located on the clayey levees of a small creek (fig. 2) and can be dated to the period 4300–4000 BC. Partial excavation was carried out at several levee sites (S2, S3, S4, and S6). Of these, S3 was the best preserved and most extensively investigated. Some 90% of the 600-m^2 site was researched. The levees differ in width; near S3 the levee is about 80 m wide.

Both domesticated plants and plants collected in the wild are evidenced in the archaeobotanical records of these early Neolithic Swifterbant sites (table 1). In the Near East, the group of domesticated crops consists of cereals, pulses, and flax. So far, the Swifterbant record has revealed only a variety of cereals. Pulses are often underrepresented in the archaeobotanical record for several reasons. Owing to their relatively large size, the seeds of most pulses do not easily pass through the sieves. Sieving the seeds prior to food preparation will therefore have produced only a small number of discarded immature seeds. Furthermore, the vegetative parts of pulses have a lower economic value than those of cereals and therefore less chance of ending up in the archaeobotanical archive of a site. Finally, the thin seedcoat of most pulse seeds is not conducive to good preservation. Therefore, it cannot yet be determined to what extent pulses were part of the diet of the Swifterbant farmers. The complete absence of lentil seeds, which are relatively small in comparison with other pulses and have a reasonable chance of passing through the sieve, might indicate that this particular pulse was not part of the diet.

It is striking that both hulled and free-threshing cereals are found at the Swifterbant sites. The hulled cereals are represented by einkorn and emmer and the free-threshing cereals by barley and possibly bread wheat. The quantity of grains and threshing remains indicates that emmer wheat and free-threshing barley were the predominant cereals. Only the grain kernels and rachis fragments from S3 allowed identification to the subspecies level (six-row barley) (Van Zeist and Palfenier-Vegter 1981, 142).

Both P14 and Urk-E4 produced grain kernels of free-threshing barley that were still partly enclosed by their chaff.

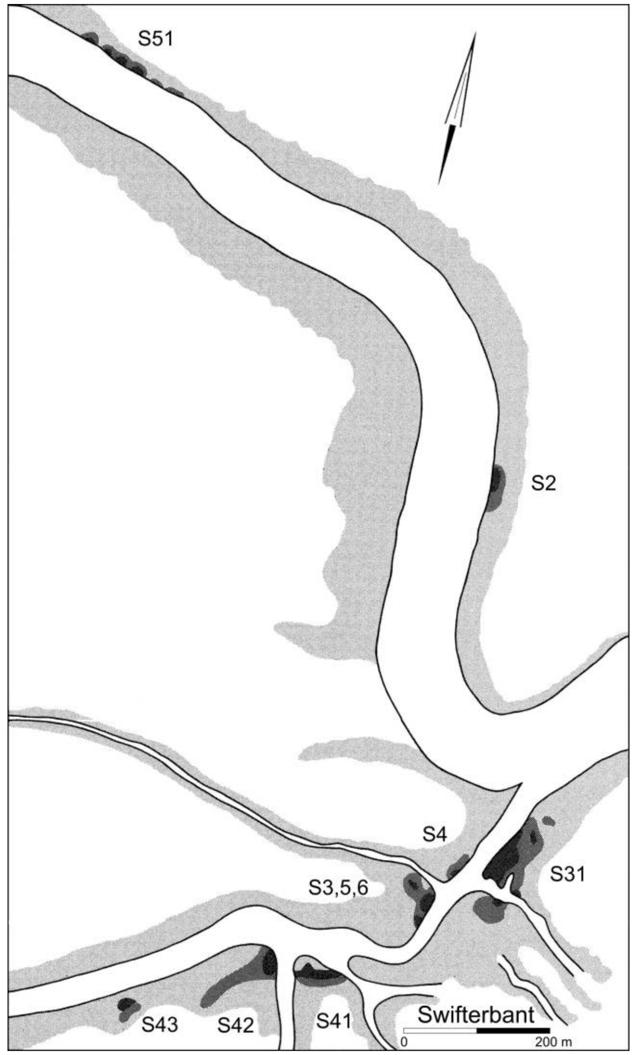

Figure 2. The levee sites of Swifterbant (after Deckers 1979, fig. 2).

It has been concluded in both cases that barley must have been harvested unripe, which would have facilitated the reaping of the crop and minimized yield losses (Gehasse 1995, 60; Vernimmen 2001, 66). This interpretation, however, does not seem to be correct. In contrast to fully ripe culms, green and unripe ones are difficult to break off. Even a single unripe culm in a handful of ripe culms will hamper the breaking off of the culms. The presence of both ripe and unripe culms is the result of uneven ripening, and this problem may have contributed to the introduction of reaping equipment such as sickles. To reduce yield losses, it is necessary to reap some weeks prior to the final stage of ripening. Then, to obtain grain kernels with low moisture content that are suitable for storage for at least a year, after-ripening should precede threshing. This implies that most grain kernels of naked barley will have been threshed and stored when fully ripe. The few grain kernels with their chaff still present most likely represent

Table 1. Edible Plants and Potential Field Weeds from Swifterbant S3, Urk, P14, Hazendonk 1, and E170.

Type and Latin Name	Common Name	Naked or Hulled	Plant Part	Sites S3	E4	P14	HD	E170
Cereals								
Hordeum vulgare ssp. *vulgare*	Six-row barley	Naked	Grain kernel	+	–	–	–	+
			Rachis fragment	+	–	–	–	–
Hordeum vulgare ssp. *distichon*	Two-row barley	Naked	Grain kernel	–	+	+	+	–
			Rachis fragment	–	–	–	+	–
Hordeum vulgare	Naked/Hulled barley	Naked/Hulled	Grain kernel	–	+	+	–	–
Triticum monococcum	Einkorn wheat	Hulled	Grain kernel	–	+	–	–	–
Triticum turgidum ssp. *dicoccon*	Emmer wheat	Hulled	Grain kernel	+	–	+	+	+
			Rachis fragment	+	–	+	+	–
Triticum monococcum/dicoccon	Einkorn/emmer	Hulled	Rachis fragment	–	+	–	–	–
Triticum aestivum	Bread wheat	Naked	Grain kernel	?	–	–	–	–
Gramineae tribe Triticeae	Cereals	?	Grain kernel	–	+	–	–	+
Plants collected in the wild								
Corylus avellana	Hazel	–	Fruit	+	+	+	–	*
Malus sylvestris	Wild apple	–	Seed	–	+	–	–	–
		–	Fruit s.l.	+	–	–	–	–
Crataegus monogyna	Hawthorn	–	Fruit	+	+	–	–	–
Quercus	Oak	–	Fruit	–	–	+	–	–
		–	Cupule	–	+	–	–	–
Rosa	Roses	–	Fruit	+	–	–	–	–
Rubus	Bramble	–	Fruit	–	–	+	–	–
Rubus fruticosus s.l.	Blackberry	–	Fruit	+	+	+	–	*
Trapa natans	Water chestnut	–	Fruit	–	–	+	–	–
Potential field weeds								
Vicia	Vetch	–	Seed	+	?	–	–	–
Vicia hirsuta/tetrasperma	Hairy tare/smooth tare	–	Seed	–	+	–	–	–
Galeopsis bifida/speciosa/tetrahit	Bifid/Large-flowered/ Common hemp-nettle	–	Fruit	+	–	–	–	–
Galium aparine	Cleaver	–	Fruit	+	+	–	–	–
Solanum nigrum	Black nightshade	–	Seed	*	–	–	+	–
Bromus secalinus	Rye brome	–	Fruit	?	–	–	+	–
Capsella bursa-pastoris	Shepherd's-purse	–	Seed	*	–	–	+	–
Chenopodium album	Fat-hen	–	Fruit	*	–	–	+	–
Fallopia convolvulus	Black-bindweed	–	Fruit	–	–	–	+	–
Persicaria maculosa	Redshank	–	Fruit	+	–	–	+	–
Polygonum aviculare	Knotgrass	–	Fruit	+	–	–	–	–
Chenopodium glaucum/rubrum	Oak-leaved/Red goosefoot	–	Fruit	*	–	+	–	–

Note: +, present; ?, identification at species level uncertain; *, preservation condition unclear or waterlogged.

immature specimens which passed through the sieve during crop processing. In fact, at both P14 and Urk-E4, only a few grain kernels were retrieved from the archaeobotanical samples, and they probably have to be considered waste products produced by either sieving or winnowing.

Of particular interest is the presence of another grass species, rye brome (*Bromus secalinus*), in the samples from Hazendonk and possibly from Swifterbant S3, where grains of soft or rye brome (*B. hordeaceus/secalinus*) have been identified. Rye brome is a grass which has become well adapted to cereal fields. It has been suggested by Bakels (1981) that it may also have been cultivated as a crop plant. In contrast to the other members of the *Bromus* genus, rye brome is characterized by a touch rachis and can therefore be considered a domesticated grass (Weeda et al. 1994). It may reach a considerable height, and its large panicle can be easily harvested together with the primary cereal, whether barley, wheat, or rye. A single plant may produce 500–1,450 spikelets (Korsmo 1954, 227).

In addition to the domesticated plants, a variety of fruits were collected. With the exception of the water chestnut (*Trapa natans*), they came from woody plants which were present in shrub vegetation and woodlands and included hazelnuts (*Corylus avellana*), wild apple (*Malus sylvestris*), hawthorn (*Crataegus monogyna*), oak (*Quercus*), roses (*Rosa*), and blackberry (*Rubus fruticosus* s.l.). There may be some bias towards hazelnuts because the large fragments of nutshell are easily recognized and were probably often thrown into fires. Such charred solid fragments are well preserved irrespective of the groundwater level and are easily isolated from the soil matrix by flotation along with the charred remains of cereals. Nevertheless, hazelnuts may be considered a staple food item which contributed to the nutritional quality of the diet. One cubic meter of whole hazelnuts is sufficient to provide 10%

of the annual energy needs of a mixed population of 20 (Cappers and Ytsma 2005). Evidence of food storage facilities, such as remains of silos, has not yet been found at the wetland sites or in the drier upland areas for the early Neolithic, and this means that the supposed importance of hazelnuts cannot be proven.

The Pros and Cons of Hulled and Free-threshing Cereals

The first step in cereal domestication was the shift from a brittle rachis to a semi-brittle or tough rachis. In this way, the scattering of ripe spikelets of cereals was reduced, and sowing became necessary to replace natural seed dispersal. The transition to agriculture can therefore be considered as the development of a symbiotic relationship between humans and the assemblage of domesticated crops.

A second step in domestication was the development of cereals with loose chaff. Such "free-threshing" or "naked" cereals still have a tough rachis that prevents the retention of ripe spikelets, the natural dispersal units of a grain, but the loosening of the chaff results in the scattering of the grain kernels instead. Strictly speaking, free-threshing cereals have regained their dispersal potential by changing their dispersal unit (diaspore): the original dispersal unit is a spikelet, whereas the new dispersal unit is the fruit (caryopsis). One could even suggest that free-threshing cereals cannot be considered full domesticated crops, for domesticated crops are by definition dependent on man for their seed dispersal.

Although both hulled and naked types of barley and wheat are evidenced from the Near East during the middle Pre-Pottery Neolithic B (PPNB), the earliest period providing clear evidence of domesticated crops (Nesbitt 2002), in Europe it appears that the cultivation of naked cereals in the early Neolithic is mainly restricted to southwestern Germany, Switzerland, the Netherlands, and southwestern Scandinavia (Küster 2000, 1228). One might wonder why both types of cereals were among the crop assemblages of early farmers in these regions.

The pros and cons of the hulled and free-threshing cereals vary with stage of crop processing (table 2). A main advantage of hulled cereals is that they can be harvested when all the grains in a field are almost dead ripe. In this stage the moisture content of the grains is reduced in relation to the amount of dry matter. As all ripe spikelets remain attached to the rachis, the grain can be harvested irrespective of the harvesting method and without serious yield losses. It is possible to collect only the ears of the hulled cereals, and whether the culms are also harvested or not depends on their usefulness.

The harvesting of free-threshing cereals is problematic because the scattering of grains may start as soon as first (upper) spikelets have become ripe. When the farmer waits until the last (lowest) spikelets have become ripe, a substantial part of the yield may be lost, even when reaping with a sickle. To solve this problem, the cereal crop has to be harvested before ripening is complete, cutting the still unripe free-threshing plants close to the ground, preferably early in the morning when the ears are covered with dew, or uprooting the whole plant. In this way the reallocation of the moisture from the grains to the vegetative parts of the plant is still possible.

The main advantage of free-threshing cereals is that the whole yield can be easily threshed when the after-ripening has been completed. The huge amounts of threshing remains which become available can be used for the production of dung cakes for fuel and for fodder or building material. Hulled cereals, on the other hand, do not produce such amounts of threshing remains. During the first stage of the threshing, the ears of hulled cereals are broken into individual spikelets which can be stored as such. A second stage of threshing is needed to free the grain kernels from their chaff and includes the parching and pounding of the spikelets. This second stage is done prior to the preparation of a meal, and as a consequence threshing remains are produced only on a small scale and have little economic importance.

Table 2. Characteristics of Hulled and Naked Cereals with Respect to Harvesting, Threshing, Transport, and Storage

Cereal Type	Harvesting	Threshing	Transport	Storage
Hulled				
Positive	When last spikelets are ripe; negligible yield losses	–	–	Grain kernels protected in chaff
Negative	–	Difficult; low quantities of threshing remains produced prior to cooking	Large volume/weight	Large volume/weight
Naked				
Positive	–	Easy; huge quantities of threshing remains that can be used as fuel, fodder and temper	Small volume/weight	Small volume/weight
Negative	When first spikelets start ripening; substantial yield losses may occur	–	–	Grain kernels sensitive to microflora

Hulled cereals have the advantage that they can be stored in the chaff, leaving the grain kernels enclosed by their natural envelope. Spikelets are adapted to survival in the soil, and in a similar way they may be protected against the microflora present in a storage bin. Compared with naked grain kernels, spikelets have the disadvantage of occupying more volume and weight in transport and storage. Whole spikelets of emmer wheat, for example, take up twice as much space as a similar number of dehusked grain kernels. If free-threshing cereals have to be transported over large distances, it makes sense to transport only the naked grain kernels. The transport of whole ears or threshing remains would make sense only when threshing remains are in high demand.

A Model for Wetland Cultivation

Crop production is possible when suitable land, water, and minerals are available. In the Near East, where the founder crops were domesticated, the availability of sufficient amounts of water is the main limiting factor. All of the founder plants, including barley, wheat, and flax, are adapted to the Mediterranean climate, with winter rainfall and dry hot summers. As typical winter crops, they complete their life cycle from October to the end of April.

The North European Plain exhibits a maritime climate with adequate rainfall. As there is no lack of water, most of the soil surface is covered with dense vegetation in which plants compete for light and minerals in particular. The availability of water in winter is, however, restricted because of frost periods, and it may therefore be assumed that winter crops began to evolve into summer crops during their spread into Western Europe. The identification of subfossil crop remains as either winter or summer crops is impossible on a morphological basis. A possible tool might be the presence of associated field weeds that may be typical for winter or summer crops. Recent studies have demonstrated, however, that the traditional classification of weed floras as summer (*Chenopodietea*) and winter (*Secalietea*) is invalid for regions with a humid climate such as the Netherlands (Schaminé, Weeda, and Westhoff 1998, 206–7). This implies that information on the former field floras in the coastal area of the western part of the North European Plain cannot be used to characterize ancient plants as either winter or spring crops.

The factors that helped shape the crop assemblage of the early farmers of the Swifterbant culture included the availability of crop species, their yield potential, and their specific use. These factors are partly related to ecological constraints and agricultural practices such as crop processing. Several models of agricultural practices have been suggested for early farming in Central Europe. Bogaard (2004) distinguishes four such models: shifting cultivation, extensive ard cultivation, floodplain cultivation, and intensive garden cultivation. These models are characterized by differences in permanence, the intensiveness of labor, and seasonality that have implications for mobility, yields, and the scheduling of labor throughout the year respectively. For the North European Plain a variant of floodplain cultivation seems to be the most plausible model. It is assumed that the higher levees of the unprotected marsh areas will have been suitable only for summer crops. Agricultural experiments in the northern part of the Netherlands have demonstrated that spring barley (both two-row [ssp. *distichon*] and six-row [ssp. *vulgare*]) can be successfully grown in an unprotected salt marsh, although yield losses due to flooding in early spring and predation can be considerable (Van Zeist et al. 1976). Spring barley is sown immediately after the frost period, in late March or early April, and can be harvested in August.

The marshy environment of Swifterbant will have been subject to winter flooding, which may also have affected the fields on the higher levees. In this way, soils were cyclically enriched with minerals, reducing the need for manuring. The natural supplement of minerals to the soil makes it possible to cultivate crops in the same spot for a long time. Whereas the Linear Pottery farmers had the advantage of the natural richness of the loess soils, the Swifterbant farmers benefited from the replenishment of nutrients by flooding. In both cases the need for mobility was reduced. A disadvantage of the flooding might have been the increase of a weed flora, resulting in competition for minerals in particular. This could have been managed by some weed control. The cultivation of cereals in rather small plots might have been advantageous in this respect, as the edges of such plots could have been easily weeded without trampling on the cereals. Such weeding is, for example, still practiced by farmers when noxious weeds such as corn cockle (*Agrostemma githago*) have become part of the weed flora (fig. 3).

Additional evidence for local cultivation of both naked and hulled cereals can also be obtained from the ecological requirements for soil conditions, including salinity, moisture regime, nutrient availability, and acidity of the associated field weeds. A prerequisite for using these proxy data, however, is that potential field weeds be unequivocally associated with the recovered crops, and this is not the case in the records of the sites studied. This is partly because of the possible contamination of the waterlogged plant remains (Gehasse 1995, 63–64; Van Zeist and Palfenier-Vegter 1981, 116; Vernimmen 2001, 66) and partly because of the sampling procedure (Van Zeist and Palfenier-Vegter 1981, 109–11).

The cultivation of both emmer wheat and naked barley may have been adopted as a risk-reducing strategy. It is most likely that the hulled and naked cereals were grown in separate fields (strip intercropping) because of their different harvesting times. Not only does naked barley have a shorter growing season than einkorn and emmer but also it is necessary to start reaping the ears as soon as the first (upper) grain kernels start ripening. The yield losses that may occur during harvesting and storage have different effects on emmer wheat and free-threshing barley (table 2). Unfavorable envi-

Figure 3. Corn cockle (*Agrostemma githago*) pulled up from the edge of a cornfield in Macedonia (May 8, 1998).

ronmental conditions such as prolonged frost periods and flooding may also be responsible for yield losses. Even complete harvests may be destroyed in this way. Barley has a shorter life cycle than wheat and can be sown when the growing season is short. Some current barley varieties even have a very high salt tolerance, but it is not clear whether such varieties were already selected in the early Neolithic. Another advantage of barley over primitive wheat species such as einkorn and emmer could have been the higher ratio of harvested to sown grain kernels, at least when six-row barley was grown. The number of grain kernels that is produced on each rachis node is three in six-row barley, whereas einkorn produces one grain kernel and emmer two grain kernels at each rachis node. To determine the seed return ratio for a complete harvest is, however, rather complicated, as it depends on many parameters, including the number of rachis nodes per ear (which may vary considerably), tilling capacity, and the trade-off between grain numbers and grain weight (Evans 1993, 260–64).

The Evidence for Local Cereal Cultivation at Swifterbant S3

What is the evidence for local cereal cultivation at Swifterbant S3? First of all, there are two pollen diagrams from the area, with cereal pollen dating just before or at the time of the occupation of the levee sites (unpublished data cited by De Roever 2004). One is located some 9 km southwest of S3 and the other ca. 13 km to the north. The diagrams suggest that cereal cultivation was practiced in the region, but this is not conclusive evidence for local cultivation at S3. Taking the problems of interpretation of cereal pollen into account (e.g., Behre 2007), this might be seen as an auxiliary argument if other arguments are convincing. Second, S3 has a large number of cereal remains. Third, study of use wear on flint artifacts carried out by Bienenfeld (1985) suggests that the few dozen artifacts the gloss on which has been interpreted as the result of work on soft plant material such as cereals are further evidence of cereal cultivation. (Bienenfeld's interpretations are now under study by A. L. van Gijn of Leiden University.) Fourth, we have a series of querns indicating the processing of plant foods, perhaps cereals (I. Devriendt, personal communication, 2005). On the basis of the pollen diagram, the cereal remains (especially the fragments of naked barley), the use-wear analysis, and the querns, we might conclude that cereal cultivation is attested for Swifterbant around 4100 BC. Nevertheless, it is clear from the quotation presented earlier that this idea is problematic.

Van Zeist and Palfenier-Vegter (1981) acknowledge the importance of threshing remains of naked barley as an indicator of local cultivation, and they propose cultivation on the highest parts of the levees. Recently, diatom analysis has been carried out at the nearby Swifterbant levee site S2 (see fig. 2) to get a better understanding of the natural environment of the site and its potential for cereal cultivation. So far, three samples have been studied, revealing that three groups of diatoms of relevance are present. A first group of marine species was transported to the site in the clay sediment, and a second group concerns species specific to an estuary environment. A third group is typical of stable surfaces and indicates that the surface was covered with new sediment for time to time. In all, we get the impression of an environment with seasons of sedimentation, perhaps resulting from storms, and seasons in which diatom populations expanded on a stable surface (De Wolf and Cleveringa 2005). The diatom analysis suggests that there were periodic (winter?) storms that led to the sedimentation of a new surface with nutrients. This enriched surface would then have been available for cultivation during the months between early spring and late summer.

As both barley and wheat are confined to well-drained soils, it is only on the natural levees that fields could have been laid out in the near vicinity of the settlements. It may not be excluded that there were also distant fields on more suitable soils, but this would imply that some group members would have had to protect them. Plant remains of associated field weeds with specific ecological preferences can be used to locate the former fields. The precondition that plant remains of (potential) field weeds and crop plants be unequivocally linked means that the two kinds of plant remains must be unearthed from the same location and equally well preserved. The extensive plant record of Swifterbant from the first field seasons did not fit this condition: concentrations of charred cereal remains and rich concentrations of waterlogged (potential) weed plants were recovered from different locations (Van Zeist and Palfenier-Vegter 1981 and table 2). The sampling procedure of the current excavations at Swifterbant is directed at the recovery of crop plants and associated (potential) weed plants but has not yet yielded sufficient data (see Kubiak-Martens 2006 for a comparative example).

Modelling of the early Neolithic landscape may be obscured by current agricultural practices that are primarily based on efficiency and profit. In the early Neolithic small fields would have been sufficient for small families whose subsistence was only partly dependent on field crops. Examples of agricultural practices which are characterized by small scale and high risk are, for example, still to be found in nomadic communities that take advantage of sporadic rainfall and expend labor and seed without the security of a sufficient yield (Cappers 2002, 2006).

Cereal Cultivation in Northern Europe

The remains of Swifterbant cultivation presented above date to the period 4300–4000 BC and thus predate the traditional transition to the Neolithic in Britain and the start of the Funnel Beaker culture in northern Germany and southern Scandinavia. While in the latter areas pre-4000-BC pollen diagrams are used to suggest the presence of low frequencies of cereal-like pollen, the Swifterbant evidence encompasses both pollen and macroremains of grains and chaff. The pollen diagrams from the Swifterbant culture are just as problematic as the diagrams in the other areas mentioned but are strengthened by the recovery of grains and chaff remains. Because botanical macroremains are found at almost all Swifterbant settlement sites, one would expect a similar abundance of macroremains at contemporaneous sites in the areas mentioned above. Their absence there suggests that the problems in interpreting cereal-like pollen mentioned by Behre (2007) must be reckoned with. It appears that the evidence of pre-4000-BC cereal cultivation in the Swifterbant culture is different from that of northern Germany.

This difference in archaeological evidence of the subsistence base between the Swifterbant culture and the Ertebølle culture of Denmark has been explained as a difference in worldview (Raemaekers 1997, 1999). The distribution of Danubian adzes in both areas makes clear that the people in these areas were part of a large contact network including Danubian farming societies in the loess belt of Central Europe and hunter-gatherers in the areas to the north (e.g., Fischer 1982; Raemaekers 1999). The transition to farming in the Swifterbant culture was apparently a matter of the small-scale incorporation of first pottery (ca. 5000 BC) and then domestic animals (ca. 4700 BC) and finally cereal cultivation (Louwe Kooijmans 2001, fig. 14.10), while the Danish evidence suggests an absence of change in subsistence until 4000 BC, when not only is the material culture of the Ertebølle culture replaced by that of the Funnel Beaker culture but also the subsistence base for the first time includes domestic plants and animals. In Holstein this transition is dated to 4100 BC, with the advent of the early Funnel Beaker Wangels group (Hartz, Lübke, and Terberger 2007). In other words, the subsistence transition in the Dutch Swifterbant culture seems to have been completed by the time it began farther north. An attractive explanation is that the small-scale Swifterbant cereal cultivation proposed above was the subsistence system subsequently found in the early phase of the Funnel Beaker culture in northern Germany and southern Scandinavia.

Conclusions

This article presents a series of arguments in favor of small-scale cereal cultivation at Swifterbant S3: pollen diagrams, cereal macroremains (especially the remains of naked barley), the diatom insight into the cyclical process of surface stability and sedimentation, and use-wear analysis. The processing of cereals is further indicated by the presence of quern stones. On the basis of these arguments and insights into both the natural environment at S3 and the characteristics of cereal cultivation, we propose that emmer wheat and naked barley were cultivated as spring crops on the natural levees of Swifterbant, areas with natural fertilization as a result of seasonal flooding. Both types of cereals were probably produced in a strip intercropping system. This system never produced optimal yields for these crops because of, among other things, their different requirements in terms of soil conditions and precipitation, but it produced reasonable yields under a wide range of circumstances. Strip intercropping also evened out the workload during the harvest. Mixed intercropping, in which naked barley and emmer wheat are sown in the same field, was not an option because free-threshing and hulled cereals are harvested in different ways (Hillman and Davis 1999).

Since the 1970s, Dutch Neolithic archaeology has considered the issue of wetland farming a problem. Our impression is that this problem is the result of our ideas about what being a farmer is all about. Assessing the agricultural potential of the area from our modern perspective, we certainly would not have chosen the levees of Swifterbant for cereal cultivation. If the pollen diagram, the cereal remains, the use-wear interpretations, and the querns had been found on loess or sand, however, everyone would have accepted local cereal cultivation. In other words, the problem of local cereal cultivation is independent of archaeological remains and solely the result of our interpretation of the local natural environment.

We suggest approaching S3's potential for cereal cultivation from a different perspective. Our knowledge of Late Mesolithic hunter-gatherer food strategies in the area suggests that they included the exploitation of a wide range of food sources to avoid dependence on a single food source. Louwe Kooijmans (1993) terms this subsistence strategy a broad-spectrum economy. In the case of the animal component of the diet, it is apparent that the introduction of domesticates did not result in a drastic change overnight. We get the impression of a limited extension of the traditional subsistence base (Louwe Kooijmans 1993; Zeiler 1997; Raemaekers 2003). If this argument is applied to the plant component of the diet, we might suppose that we are dealing with small-scale fields that were not crucial but simply an additional aspect of the subsistence strategy.

Following this line of reasoning, we would expect to find hunter-gatherer-farmers of the Swifterbant culture occupying especially the wetlands areas, with their varied resources of wild plants and animals. From this perspective, the drier uplands would have been less suitable because of their relatively homogeneous natural environment, and Swifterbant sites would be expected to occur especially in gradient zones such as the borders of stream valleys. Unfortunately, there is little evidence to support or counter this suggestion. Poor preservation conditions in the sandy soils would have reduced Neolithic sites to flint scatters, which, moreover, have not yet been found in the uplands (Raemaekers 1999). One line of evidence is a series of stray finds from the Noordoostpolder. During the Neolithic, parts of this polder were an upland cover-sand area; after the Neolithic the area was covered and protected from degradation by Holocene deposits. When the stray finds are plotted on a palaeogeographic map, it becomes clear that many of them are located near streams (Gehasse 1995, maps 1–4). Unfortunately, it is not clear whether these finds represent the early phase of the Swifterbant culture, for which there is no evidence of cereal cultivation, or the latter part, for which cereal cultivation is attested.

On the basis of the proposed small-scale cereal cultivation at Swifterbant S3 and the suggestion that these communities preferentially occupied natural environments in which hunting, gathering, animal husbandry, and cereal cultivation could be undertaken (that is, gradient-rich wetland zones), we now return to the functional relations between wetland and upland communities. As mentioned in the introduction, the general idea has been that cereal cultivation was less important in the wetlands than in the uplands. If we recognize the etic view implicit in this interpretation and accept the attractiveness of gradient-rich wetlands for hunter-gatherer-farmers, we might argue that wetlands were especially important for the people of the Swifterbant culture. Swifterbant occupation of the uplands, of which we know very little, was located either in gradient-rich zones such as the banks of streams or on the relatively gradient-poor cover-sand plateaus. In the latter case, the wetland subsistence strategy would have to have been different in one of two respects. We might envisage the relative low diversity of natural plant resources to have been compensated for by greater reliance on cereal cultivation or the transport of wild plant resources to the agricultural sites.

Comments

Graeme Barker
McDonald Institute for Archaeological Research, University of Cambridge, Cambridge CB2 3ER, UK (gb314@cam.ac.uk). 15 I 08

The principal conclusion of the paper is persuasive—that by the late fourth millennium BC the hunter-gatherers who camped at Swifterbant were also engaging in cereal cultivation on the levees in that estuarine locality rather than obtaining cereals by trading with agricultural populations farther inland. Though that cereal cultivation was probably on a small scale compared with hunting, fishing, and gathering, it seems clear that the complementary advantages of the different harvesting periods and the threshing and storage properties of free-threshing and hulled varieties of cereal crops were well understood—their cultivation was not some kind of haphazard experimental activity, so it is not clear why the authors refer to it as a "test array." The suggestion that cultivation for these forager-farmers was essentially a spring and summer activity on natural levees the nutrient levels of which would have been renewed annually by flooding has been made for some time in the case of the mobile "First Neolithic" forager-farmers of other wetland landscapes such as along the Tisza and Körös Rivers in central Europe, even though wetland cereal cultivation has hitherto been regarded as problematic by Dutch archaeologists. It appears to have been a combination of the third and fourth of Bogaard's (2004) models of early European crop husbandry (floodplain cultivation and intensive garden cultivation).

The Swifterbant sequence, with domestic animals appearing in the archaeological record in the early-to-mid-fourth millennium BC, followed several centuries later by evidence for cereal cultivation, is mirrored in the comparable wetland landscapes of the Schelde estuary in Belgium (Crombé et al. 2002). They are part of the generally piecemeal adoption of the "Neolithic package" evident across northwestern Europe from Brittany to Scandinavia through the fourth millennium BC, followed by the rather rapid development of a significant commitment to mixed farming. The interesting question in the Swifterbant example, as elsewhere, concerns the role—or, more likely, roles, differing in time and place—of domestic animals and plants for the Mesolithic populations engaging with them through these centuries. Were these new resources valued for their potential role as supplementary or replacement food staples to enhance dietary range? Or because of their value for risk avoidance strategies to deal with pressure points in the annual subsistence cycle? Or for their exoticness, for the enhanced status they gave their owner? Or the magical brewing qualities of cereals? No doubt the pathways leading individuals and small-scale societies into a developing engagement with domesticates across northwestern Europe and an eventual commitment to agriculture were many and various, as must have been the perceptions of the threats and opportunities represented by the new animals and plants. The challenge for European prehistorians now is not only to theorize some of the behaviours that the catch-all and inadequate term "acculturation" at the Mesolithic-Neolithic transition might have entailed but also to develop robust methodologies capable of identifying them. Detailed interdisciplinary studies of selected landscapes such as the Swifterbant Project surely offer some of the best data sets for this next essential stage in Neolithic archaeology.

Amy Bogaard
School of Archaeology, Oxford University, 36 Beaumont St., Oxford OX1 2PG, UK (amy.bogaard@arch.ox.ac.uk). 14 XII 07

The paper by Cappers and Raemaekers is a careful and thought-provoking contribution to the Mesolithic/Neolithic-transition literature for north-west Europe. As is discussed by Louwe Kooijmans (e.g., 2007) and elaborated here, cereals emerge in the Dutch wetland sequence some centuries after the incorporation of domestic animals into the "broad spectrum" of Late Mesolithic foodways. Thus the combination of domestic animals and crops seen so consistently across Europe finally appears to unravel, albeit temporarily, at this north-western fringe of continental Europe. Importantly, when crops such as naked barley and emmer wheat do make their appearance in the Dutch wetlands, it is, Cappers and Raemaekers argue, a result of their small-scale *local* cultivation on levees and not (as previously argued) of their transport from more distant upland farming areas. In other words, the Late Swifterbant people were "wetland farmers" as well as herders, hunters, and fishers.

In the absence of intact arable palaeosols (tentatively identified in the Dutch case at one river dune site, Urk E-4), it is difficult to pinpoint the location of arable fields archaeologically. The lines of indirect evidence cited in support of local wetland cultivation (presence of a naked barley rachis, which is separated off at an early stage of crop processing; regional pollen spectra suggesting cereal cultivation; silica gloss on chipped stone tools; querns) are not individually or even collectively conclusive, as Cappers and Raemaekers acknowledge. Stronger evidence of local cultivation might be provided by the ecological profile of arable weeds harvested with crops and incorporated with them into archaeological deposits. Kubiak-Martens (2006) has constructed an impressive case for wetland cultivation in the mid-fourth millennium cal BC at Schipluiden, where a weed flora partly derived from the local salt-marsh environment is associated with crop remains. Potential weeds at the Swifterbant-culture sites (table 1) are "generalist" species and cannot be used to distinguish between local/wetland and distant/dryland cultivation (Bakels 2000). Their association with crop remains is also uncertain, though it can at least be noted that these species are annuals of nutrient-rich habitats and therefore consistent with small-scale intensive cultivation. In the absence of reliable weed data or as a complement to it, additional evidence for farming location may be available through stable-isotope analysis of charred cereal remains (cf. Araus et al. 1997; English et al. 2001; Bogaard, Bending, and Jones 2007), if strontium, carbon, and/or nitrogen ratios can be shown to distinguish levee from upland locales.

If we accept the indirect arguments made for local cultivation of spring-sown crops on levees, it is worth considering how this form of farming compares with what is known of cultivation on the loess belt. There appears to be general agreement that earlier Neolithic cultivation areas in the western loess belt were relatively long-lived and small in scale (e.g., Rösch 2000; Kalis, Merkt, and Wunderlich 2003; Bogaard 2004; Kreuz 2007). The eventual adoption of cultivation in a wetland environment with limited dry land could therefore represent the logical extension of a small-scale/intensive approach to farming. Indeed, similar adaptations were made elsewhere in Europe, such as in the wetland environment of the Körös culture in south-east Hungary, where a case for local cultivation of high/dry land has incorporated several lines of evidence, including archaeobotanical, faunal, and soil micromorphological data (Bogaard et al. 2007).

Cappers and Raemaekers characterize the Swifterbant regime as "floodplain cultivation," linking it with a general model of early farming on alluvial soils from western Asia to Europe (Sherratt 1980). Within the loess belt of central Europe, floodplain cultivation has been questioned on archaeobotanical grounds (Bogaard 2004), to which can be added the results of geomorphological work showing that floodplain loam was generally a post-Neolithic development resulting from accelerated erosion and alluviation as the scale of agriculture expanded (e.g., Wunderlich 2000; Lang 2003). Though floodplain cultivation has been associated with the "colonization" of new environments by incoming farmers (Bogucki 1996), it is arguably most relevant to those resource-rich wetland regions of Europe where an indigenous adoption of agriculture is widely acknowledged.

One argument developed by Cappers and Raemaekers with much wider implications is that archaeologists have too easily dismissed wetland environments as inappropriate for early cultivation. While such environments do not appear optimal from a modern agronomic perspective, it is entirely plausible that early farmer-herder-hunter-fishers with a broad subsistence base perceived them very differently. Detailed archaeobotanical investigations are needed to reveal the "otherness" of early farming and in particular its small-scale and intensive nature, which (I would argue) ultimately paved the way for its adaptation to an amazing range of environments—all the way to the coastal wetlands of the Netherlands.

James Innes
Geography Department, University of Durham, South Road, Durham DH1 3LE, UK (j.b.innes@durham.ac.uk). 3 I 08

Cappers and Raemaekers's paper is a timely and valuable contribution to the often heated debate regarding the process of Neolithization in north-west Europe and in particular the role of palaeoenvironmental, especially palaeobotanical, evidence in the study of that critical period of culture change. Archaeological and radiocarbon data indicate that the transition to agriculture in the coastal lowlands of Atlantic and Baltic Europe was a protracted process. Unlike the swift replacement of hunter-gatherer groups that occurred earlier in the advance of Neolithic culture across Europe, the switch from fully Mesolithic to clearly Neolithic cultures may have taken several centuries in these north-western European lowland fringes, with a long-term, largely static contact zone between agricultural and foraging groups established there. Well-established trading links and social contacts across this stable Mesolithic/Neolithic cultural boundary along the north and north-western coastal lowlands (Hartz, Heinrich, and Lübke 2002) would inevitably have led to cultural transmission and thus a blurring of cultural signatures. The Swifterbant culture of the lowland wetlands of the Netherlands area is only one of several in this northern borderland region that seem to span the transition from Late Mesolithic to Early Neolithic and exhibit acculturation and the periodic adoption of elements of Neolithic culture rather than swift assimilation or replacement. The reasons for this major reduction in the pace of culture change may have had much to do with the extensive wetland ecosystems in these coastal lowlands and the presence in these areas of well-established, relatively sedentary foraging societies with substantial populations exploiting rich and reliable marine and other wetland resources. It would have been difficult for the new subsistence farming techniques of the Neolithic to supersede these existing, well-adapted foraging economies, and this would have prevented the rapid introduction of the whole Neolithic cultural package. Land-use transformations under forest farming systems during the Mesolithic/Neolithic transition in these lowland areas were probably subtle and small-scale, perhaps having little recognizable expression in material culture and therefore not easily visible in the archaeological record. It is probable that here the very early Neolithic may be understandable only through the addition of palaeoenvironmental data to the artifactual record. The value of pollen analytical data, however, is extremely contentious in the context of the Mesolithic/Neolithic transition and the introduction of cereal cultivation because of the uncertainty regarding the identification of wild grass and cereal pollen and the possibilities of factors such as contamination (Behre 2007; Joly et al. 2007; Tinner, Nielsen, and Lotter 2007). At many sites, however, in the absence of more direct archaeological and plant macrofossil evidence, pollen records may be the only available signature of the earliest cereal cultivation and forest farming by the first local Neolithic settlers or conceivably by indigenous Late Mesolithic groups in the process of culture change and adopting novel techniques.

Most cereal-type pollen records of Mesolithic/Neolithic-transition age in north-west Europe have been, unsurprisingly, recovered from wetland sediments (Innes, Blackford, and Davey 2003; Innes, Rowley-Conwy, and Blackford 2003) without the supporting evidence of cereal macrofossils and cereal-processing artifacts that would prove cultivation. Many authors therefore, intuitively considering the location of pioneer cultivation in wetland environments implausible, have dismissed these very early, unsupported, and problematical cereal-type pollen identifications as erroneous (Behre 2007; Brown 2007). Cappers and Raemaekers's paper, however, demonstrates that lowland wetlands in reality can be very suitable locations for small-scale cereal cultivation in small plots as part of a forager-farmer exploitation of the complex and resource-rich wetland ecosystem. Their alternative early Neolithic subsistence model of wetland farming is based on real data, with cereal-type pollen evidence supported by macrofossils of cereals and other cultivation-related plants as well as querns. Wetland location would even have been advantageous, with seasonal flooding of levee sides providing new nutrient-rich sediments every year to small cereal plots that were simply an additional contribution to a very diverse wetland resource base that had been exploited throughout the Mesolithic/Neolithic transition. Cappers and Raemaekers have made a major contribution to the debate on the introduction of cereal cultivation to north-west Europe by providing irrefutable evidence from a wetland environment of early Neolithic cereal cultivation and processing and thus, at this site at least, increasing significantly the likely validity of the associated cereal-type pollen as a signature of cereal growing, one of the requirements stipulated by those disinclined to accept early cereal-type pollen data (Behre 2007). In north-west Europe, throughout the period of the first introduction of agriculture, such slightly elevated locations within wetlands may have been highly suitable for the creation of small, even experimental cultivation plots that were not critical to the survival of a broadly based forager-pastoral society. Cereal-type pollen records from wetlands of earliest Neolithic and Mesolithic/Neolithic-transition age therefore need to be scrutinized seriously as possible early cultivation locations, and many more wetland archaeology sites of these periods require high-resolution, integrated palaeoenvironmental study.

Stefanie Jacomet
Institute for Prehistory and Archaeological Science, Basel University, Spalenring 145, CH-4055 Basel, Switzerland (stefanie.jacomet@unibas.ch). 14 I 08

This paper is valuable in tracing and analysing the early diffusion of agricultural practices in a marginal region. How and why hunter-gatherers embark on new economic practices such as farming is still a matter of much debate, and the botanical evidence is a very important part of this debate. Off-site pollen data are difficult to interpret, as Behre (2007) has recently shown. On-site archaeological evidence from the crucial time span, which includes not only botanical data but also tools, is therefore much more important. The Atlantic coast of Northern Europe is one of the very few areas where excellent on-site data on the Mesolithic are available, but they are not really considered here. For a better understanding of early agriculture in wetlands, the paper should have at least included a brief overview of Mesolithic subsistence in the area (see, e.g., Crombé 2005; Bakels and van Beurden 2001; Perry 2002; Kubiak-Martens 2002; Robinson and Harild 2002; Mason and Hather 2002). Diffusion and population movements certainly played a crucial role in the spread of innovations like agriculture, but the authors fails to discuss the ongoing debate on a theoretical level (e.g., omitting the very useful compilation on the Neolithization of the Atlantic coast by Arias (1999) and the work of Zvelebil (1986, 1998) and Price (1996). As a result, it is not easy to position the contents of their paper within a supraregional and longer chronological framework.

Cappers and Raemaeker's compilation of the available on-site botanical data of the earliest Neolithic in the Dutch coastal region is incomplete (omitting Rijswijk-Ypenburg [van Haaster 2001], Wateringen 4 [Raemaekers et al. 1997], and Schipluiden [Kubiak-Martens 2006]), and, while they say that we are dealing with "well-preserved wetland sites," taphonomy (e.g., the appearance of the archaeological layers or structures that yielded botanical remains) is not really considered. In addition, the list of data in table 1 is quite superficial, and important information such as type of context, number of contexts sampled, volume of the samples, smallest mesh-size used, preservation of the remains) is lacking. Also, some quantification of the data would have been helpful (e.g., as in Robinson 2003). As compiled, these data do not give us much insight into what was found in the sites, and this makes it difficult to follow the argumentation.

For instance, it is crucial to know whether carbonized and uncarbonized remains come from the same contexts. In the Alpine Neolithic lakeshore settlements, cereals are found both carbonized and uncarbonized, whereas all other plant remains are largely waterlogged (uncarbonized). This is because cereals had a better chance of becoming carbonized than other useful plants (see Willerding 1991; Jacomet, Brombacher, and Dick 1989, 115, table 32). In the plant spectra from Neolithic settlements on dry ground, only carbonized plant remains are found for taphonomic reasons (see, e.g., Jacomet 2007, 2006, 2008). Here cereals dominate in the useful-plant spectrum, and one gets the impression that the growing of cereals was of crucial importance for subsistence when this was not necessarily the case. The greater frequency of wild plants in the coastal sites of the Swifterbant culture may therefore be mainly due to taphonomy.

To be able to assess the on-site data it would have been important to discuss how a site can be called a producer site on the basis of archaeobotanical facts. The identification of early stages of crop processing is crucial. These can be shown by the presence of chaff (especially of naked cereals) and by an analysis of the size and weight of weed seeds (see Hillman 1984; Jones 1987). The presence of rachis remains of naked barley and additional evidence from the material culture such as sickles with gloss and quern stones indicates that cereals were grown locally and cleaned on site at Swifterbant 3. Several models for early farming have been suggested. A relevant one for the interpretation of a possible Swifterbant agriculture is that of Bogaard (2004), who proposes horticulture on small plots of land as a cereal-growing strategy in Neolithic Central Europe (by evaluating the functional attributes of weeds [see, e.g., Jones et al. 2005]). Ample evidence from Central European Neolithic lakeshore settlements points to such a strategy (see, e.g., Hosch and Jacomet 2004), although some still speak of shifting cultivation (Rösch et al. 2002). As a result, the proposed way of growing cereals during Swifterbant times does not seem to be very different from that of the Neolithic communities of Central Europe. Unfortunately, the Swifterbant weeds cannot be clearly connected with the cereals.

In conclusion, (summer) cereal growing in coastal Swifterbant sites seems to be a plausible explanation of the data set available, but a really reliable compilation of all the available data is required. Only then can the various hypotheses be properly tested and crucial questions such as why the Atlantic Mesolithic groups became cultivators and how external innovations were internalized be finally answered.

Malcolm C. Lillie
Wetland Archaeology & Environments Research Centre, University of Hull, Hull HU6 7RX, UK (m.c.lillie@hull.ac.uk). 06 XII 07

Cappers and Raemaekers present an interesting model for wetland cultivation, but, surprisingly, they fail to provide any real evidence to support it—an unusual omission, given that both of them have researched this topic in some depth.

Generally, the evidence for cereals at Swifterbant sites is well established for the period ca. 4300–4000 cal BC (e.g., Out 2008). Despite this, the five sites used in this paper provide differing levels of reliability in relation to the identification of the earliest dates for cultivation. It is apparent from the data presented that the first four sites used (Hazendonk, Urk-14, Schokland P-14, and Schokkerhaven) represent only weak support for the proposed model. The final site is more promising, as Swifterbant S3 appears to have very good evidence for the presence of cultivated crops. Although some inherent limitations exist in relation to reliance on work published in the early 1980s, it can be argued that the evidence for cereal remains, gloss on flint, and querns at Swifterbant S3 is clearly much more reliable as an indicator of the presence of crops and their harvesting and processing than the evidence from the four other sites discussed.

The poor dating resolution at many sites and lack of definitive evidence for cultivation on the dune systems in the Netherlands weakens the model considerably. The proposed low-risk scenario for cultivation on dunes is unsupported, the lack of dated pollen diagrams is problematic, and the failure to link dated pollen diagrams and plant macroremains is frustrating. It is also worth pointing out that the diatom evidence discussed does not preclude flooding episodes outside of the winter season. In addition, the work of Brinkkemper et al. (1999) has shown that, at the site of Hoge Vaart, near Almere, Schokland, changing hydrological conditions led to abandonment after ca. 4500 cal BC. These data would reinforce the observation that cultivation in the wetlands would have been unlikely to be perceived as a low-risk situation by the Swifterbant culture groups across the period ca. 4300–4000 cal BC

Despite these observations, cereals are clearly part of the Swifterbant subsistence economy. The visibility of these cereals at the sites studied may be reduced because different sites in the wetlands have different functions at different times of the year and occupation/activity episodes will have had differing durations depending upon site function (see Brinkkemper et al. 1999, 84). A weakness in the model resides not simply in our inability to identify wetland cultivation on dunes as a possibility but more in the fact that we do not have sufficient data to identify the diversity inherent in the exploitation of the wetlands in general.

At the site of Branwijk-Kerhof (Alblasserwaard, Zuid-Holland) (Out 2008), the pollen and plant macrofossil evidence from Zone DIII suggests that some level of agricultural activity is occurring at ca. 4000–3800 cal BC, with crops being introduced sometime between 4220 and 3940 cal BC, on the evidence from the sites of Branwijk-Kerhof and Hardinxveld-Giessendam (Out 2008). Out (2008, 37) notes that it is not clear whether cereals were cultivated locally or whether they were cultivated in the nearby southern sandy regions outside the marsh and imported. The limitations inherent in the data (see Louwe Kooijmans 2003, 622) are supportive of local cultivation but could equally be used to argue against anything more than simple crop processing.

The argument appears to be somewhat circular, and given the available evidence the proposed model is difficult to substantiate. It is clear that the evidence from the various sites differs in quality and the activities attested at the sites vary. Perhaps the concept of horticultural activity should be refined to accommodate the idea that we simply do not fully understand the activities of these horticulturalists. Sites would have been exploited intermittently, and therefore the evidence will be reflecting piecemeal activity and the reuse of dune surfaces that have previously been cleared for crop production. These are, then, potentially, left for a number of seasons or interannually for reasons such as intermittent flooding, shifting exploitation strategies, and being left fallow because of shifts in nutrient status.

The concept of wetland cultivation is not inappropriate in the context of the Swifterbant culture, but the evidence to confirm it is lacking. What I am suggesting is that the diversity of activity within the wetland zone weakens the model not because of our inability to understand wetland cultivation but because we cannot tease out the relevant evidence for horticultural activities from the multiple occupations at the sites studied to date.

Peter Rowley-Conwy
Department of Archaeology, University of Durham, South Road, Durham DH1 3LE, UK (p.a.rowley-con@durham.ac.uk). 7 I 08

This paper makes its main point convincingly and well: cereal cultivation at the Swifterbant wetland sites would indeed have been possible, and the cereal remains found at these sites need not have been imported from "producer" sites elsewhere. Previous views of the unsuitability of the Swifterbant sites have been based on modern understandings of what constitutes suitable agricultural terrain. As the authors note, their proposed model of small-scale cultivation fits well with what has recently been documented by Bogaard (2004) for the Linear Pottery culture by means of detailed studies of weed floras. The suggestion that crops were planted on the levees in the spring after the recession of the floodwaters seems eminently plausible. Long-distance movement of significant quantities of cereals has always seemed rather unlikely to me, even in an area such as western Holland where part of the journey might be made by boat. For any part of the trip that could *not* be made by boat, only human transport would have been available, and this would have been a major limiting factor.

Cappers and Raemaekers are right to stress the evidence from naked barley in support of their case. Cereals for transport would have been processed at their point of origin in order to remove the bulk. A free-threshing cereal such as naked barley or bread wheat would have ended up as naked grains during this process and have been transported as such—a point made long ago by Gordon Hillman (1981, 142). The presence of barley chaff at Swifterbant S3 and Hazendonk indicates that the barley was processed on site, which thus favours the argument that it was grown locally rather than imported. Table 1, however, records not numerical totals but only presence and absence. If barley chaff is present in substantial quantities on these two sites and is proportionately common in comparison with grains, this would reinforce the argument for local cultivation It is a pity, therefore, that this information is not presented.

The current picture of early agriculture in western Holland is thus, as Cappers and Raemaekers state, that domestic animals appear rather earlier than cultivated cereals. There is no particular reason that this should not be the case, but it would mean that western Holland would differ from other areas in northwestern Europe, where domestic animals and cereals appear much closer together in time. This is a question on which future research will no doubt cast light; in the meantime we need to remember that wild and domestic animals can be difficult to distinguish—and direct AMS dates on the cereal grains discussed here would also be important.

Cappers and Raemaekers understandably appear a little ambivalent about the utility of pollen analysis in identifying the earliest agriculture. This is a question relevant not just to the southern North Sea region but also to more northern areas such as Norway (Prescott 1995). They quote the strong critique of the pollen evidence for "Mesolithic agriculture" by Behre (2007), and this may weaken somewhat their use of pollen as a line of evidence supporting local cultivation at Swifterbant S3. But the macrobotanical cereal evidence from this site appears sufficient by itself to support their main argument. In this way the Swifterbant sites are similar to though a little earlier than sites in southern Scandinavia and Britain—their opening statement about "pollen diagrams only" in these regions refers to the Mesolithic, not to the Neolithic, for which numerous macrobotanical cereal assemblages are available (Brown 2007; Jones and Rowley-Conwy 2007; Robinson 2003). In disposing of the older arguments for cereal importation, Cappers and Raemaekers have made a substantial contribution to our knowledge of early cultivation in northwestern Europe. Let us hope that other workers and other sites will in due course add to this.

Reply

The benefit of the various responses is that they allow us to determine the general reaction to our paper and make perfectly clear where more work needs to be done. We thank the commentators for their input and hope that our reply does justice to their critiques. In this response we will offer some general remarks in response to some of the comments and an answer to the challenge to present more archaeological data to support the model.

One minor issue, presented by Rowley-Conwy, is the notion that the process of Neolithization in the Swifterbant culture is different from that in the northern European Ertebølle culture. The early finds of the bones of domestic animals would indeed be problematic if they were only those of pig or cattle, but in the Dutch case the bones of these domesticates are accompanied by bones of sheep or goat (Louwe Kooijmans 2007). Because wild sheep or goats are unknown from the northwestern European Mesolithic, these bones are decisive evidence of the presence of domestic animals around 4700 cal. BC. It appears that the process of Neolithization in our area does indeed differ from that of other areas in northwestern Europe.

A second issue, mentioned by Jacomet and Bogaard, is the existence of other Dutch wetland sites, in particular the coastal dune site of Schipluiden. Although these sites are relevant from a broader spatial-temporal perspective, both their date (several centuries younger) and their environmental setting (dune versus the clay levees of Swifterbant) set them apart. A crucial aspect of the discussion of cereal cultivation at Swifterbant is that it took place in an environment that was unsuitable from a modernist perspective. This condition does not apply to Schipluiden.

Our model of wetland farming is based on a revaluation of the Swifterbant levees as attractive to prehistoric people with a broad-spectrum risk strategy in which cereal cultivation played an auxiliary role in a traditional hunter-gatherer subsistence system. The typical occurrence of emmer wheat and naked barley on Swifterbant sites fits this notion well. Additional evidence of local crop cultivation can be obtained from the ecology of the field weeds. It is assumed that species indicative of moist soils with a moderate to high nutrient availability took advantage of the new habitat. It should be recognized, however, that modern field weed associations are the result of prolonged and unconscious selection of plants in which synchronization of flowering period and the mechanism of seed dispersal were important criteria. As can be judged from current fields, the most successful invaders are characterized by seed ripening during harvest and the capacity to contribute diaspores partly to the soil seed bank and partly to the stock supply. In this way, part of the diaspores will be sown with the crop in new fields. The species assemblages of prehistoric fields may therefore have differed from modern ones. Basically, those of early fields will have been composed of both the wild plants that were present in the sowing seed and the local wild plants that were adapted to the local soil conditions and human disturbance. Hillman (1982) has shown that even biennial plants such as *Danthonia descumbens* could thrive in fields ploughed with primitive tools or ards, preventing the soil from being turned over and the plants buried before seed release.

Although cereals as well as wild plants have been found at Swifterbant in reasonable quantities, a correlation between crop and field weeds cannot yet be established, as they were predominantly found in different samples and, moreover, were differently preserved. An alternative signal might be obtained from clear differences in seed quantities. Former arable palaeosols will be characterized by a shift in the seed flora indicating the increase of species already present in the environment and the possible introduction of new species. This kind of evidence does not necessarily have to be linked with the co-occurrence of crop plant remains.

Threshing remains of naked celereals are scarce at Swifterbant sites, but this can be explained by assuming that threshing was not done on the site proper because it required a good threshing floor and produced much dust. The low concentrations of cereal pollen do not necessarily have to be considered as poor evidence for local cultivation (see Behre 2007). The dispersal of pollen from barley and wheat is rather poor, as is demonstrated by a pollen core sampled in the near vicinity of a prehistoric field that offers only a weak signal of cereal pollen (Bakels 2000*b*). This implies that even weak signals of cereal pollen may be indicative of local farming, especially when, as is the case at Swifterbant, other kinds of evidence are also available.

Most of the commentators call for more archaeological data to strengthen our model of Swifterbant cereal cultivation. Groningen University has been conducting new excavations at the Swifterbant levee sites since 2004. One of the major research goals is to gather more information on the issue of cereal cultivation. Here we would like to give a short summary of the research lines involved and some initial results.

The first line of research is that of botanical macro remains. In the 2004 campaign at S2 a new sampling strategy was tested in which all of the soil was sampled in 50 × 50-cm squares (5-cm spits), wet-sieved using a sieve with a 2-mm mesh, and screened for the presence of cereal grains. For all squares 11 soil samples were kept in reserve to be analysed in greater detail (with smaller mesh sizes) if grains were indeed recovered. Although cereal grains were recovered in small numbers from many squares, no further botanical material was found in the accompanying soil samples. It was concluded that the preservation conditions at S2 were insufficient for our research. In 2005 the research shifted to S4, a levee site neighbouring S3 (the well-preserved site researched by Van Zeist in the 1970s). The same sampling strategy yielded similar results: although cereal grains were found across the site, the soil samples proved sterile. We conclude that, except at S3, this line of research is frustrated by the insufficient preservation conditions.

Pollen samples from the levee sites suffer from similar shortcomings and provide little pollen. This is probably also the result of preservation conditions. A more promising line of research is the analysis of diatoms to determine the natural environment of the levee sites. Now that the preservation of diatoms is attested (see above), it may be possible to search for specific contexts within our sites with diatom species typical of cereal fields.

Thin-section analysis provides us with such possible contexts. The Dutch National Service for Archaeology, Cultural Landscape, and Built Heritage is involved in excavations to gather information on the Swifterbant sites, and Huisman's thin sections provide us with intriguing insights into those sites. He concludes that at both S2 and S4 there is evidence of anthropogenic soil disturbance: "Layer II consists of the same silty clay, but is decalcified. Moreover, the layer contains large amounts of organic matter, burnt plant material, and (burnt) bone. This material shows a random distribution and orientation, indicating that the layer has been thoroughly mixed. . . . The micromorphological evidence now shows that tillage for the growing of crops—including cereals—was possible" (Huisman, Raemaekers, and Jongmans n.d.). The Swifterbant excavations will continue to focus on cereal cultivation, examining thin sections and the distribution of diaspores from potential field weeds in different layers. Further research will, we hope, provide us not only with micromorphological evidence of tillage but also with macroscopic soil traces.

—R. T. J. Cappers and D. C. M. Raemaekers

References Cited

Araus, J. L., A Febrero, R. Buxó, M O. Rodríguez-Ariza, F. Molina, M D. Camalich, D. Martín, and J. Voltas. 1997. Identification of ancient irrigation practices based on the carbon isotope discrimination of plant seeds: A case study from the south-east Iberian peninsula. *Journal of Archaeological Science* 24:729–40. [AB]

Arias, P. 1999. The origins of the Neolithic along the Atlantic coast of continental Europe: A survey. *Journal of World Prehistory* 13:403–64. [SJ]

Bakels, C. C. 1981. Neolithic plant remains from the Hazendonk, Province of Zuid-Holland, the Netherlands. *Zeitschrift für Archäologie* 15:141–48.

———. 1986. Akkerbouw in het moeras? In *Rotterdam Papers 5: A contribution to prehistoric, Roman, and medieval archaeology,* ed. M. C. van Trierum and H. E. Henkes, 1–6. Rotterdam.

———. 1991. Western continental Europe. In *Progress in Old World palaeoethnobotany: A restrospective view on the occasion of 20 years of the International Work Group for Palaeoethnobotany*, ed. W. van Zeist, K. Wasylikowa, and K.-E. Behre, 279–98. Rotterdam and Brookfield: Balkema.

———. 2000*a*. The Neolithization of the Netherlands: Two ways, one result. In *Plants in Neolithic Britain and beyond*, ed. A. S. Fairbairn, 101–6. Oxford: Oxbow Books. [AB]

———. 2000*b*. Pollen diagrams and prehistoric fields: The case of Bronze Age Haarlem, the Netherlands. *Review of Palaeobotany and Palynology* 109:205–18.

Bakels, C. C., and L. M. van Beurden. 2001. Archeobotanie. In *Archeologie in de Betuweroute Hardinxveld-Giesendam Polderweg een mesolithisch jachtkamp in het rivierengebied (5500–5000 v. Chr.)*, ed. L. P. Louwe Kooijmans, 325–78. Amersfoort.

Behre, K.-E., 2007. Evidence for Mesolithic agriculture in and around central Europe? *Vegetation History and Archaeobotany* 16:203–19.

Bienenfeld, P. 1985. Preliminary results from a lithic use-wear study of the Swifterbant sites S51, S4, and S2 (Swifterbant Contributions 13). *Helinium* 25:194–211.

Bogaard, A. 2004. *Neolithic farming in Central Europe: An archaeobotanical study of crop husbandry practices.* London: Routledge.

Bogaard, A., J. Bending, and G. Jones. 2007. Archaeobotanical evidence for plant husbandry and use at Ecsegfalva 23. In *The Early Neolithic on the Great Hungarian Plain: Investigations of the Körös culture site of Ecsegfalva 23, Co. Békés*, ed. A. Whittle, 421–45. Budapest: Hungarian Academy of Sciences. [AB]

Bogaard, A., T. H. E. Heaton, P. Poulton, and I. Merbach. 2007. The impact of manuring on nitrogen isotope ratios in cereals: Archaeological implications for reconstruction of diet and crop management practices. *The Journal of Archaeological Science* 34:335–43. [AB]

Bogucki, P. 1996. The spread of early farming in Europe. *American Scientist* 84:242–53. [AB]

Brinkkemper, O., W-J. Hogestijn, H. Peeters, D. Visser, and C. Whitton. 1999. The Early Neolithic site at Hoge Vaart, Almere, the Netherlands, with particular reference to non-diffusion of crop plants, and the significance of site function and sample location. *Vegetation History and Archaeobotany* 8:79–86. [MCL]

Brown, A. 2007. Dating the onset of cereal cultivation in Britain and Ireland: The evidence from charred cereal grains. *Antiquity* 81:1042–52. [JI, PR]

Cappers, R. T. J. 2002. Farming in the desert: Implications of recent practices for archaeobotanical interpretations In *Moving matters: Ethnoarchaeology in the Near East,* ed. W. Z. Wendrich, 45–62. Leiden: Centre of Non-Western Studies.

———. 2006. *Roman foodprints at Berenike: Archaeobotanical evidence of trade and subsistence in the Eastern Desert of Egypt.* Cotsen Institute of Archaeology Monograph 55.

Cappers, R. T. J., and W. A. Ytsma. 2005. Hazelnoten en mobiliteit in het Boreaal. *Paleo-Aktueel* 14–15:21–26 (with English summary).

Crombé, P., ed. 2005. *The last hunter-gatherer-fishermen in Sandy Flanders (NW Belgium).* Vol. 1. *The Verrebroek and Doel Excavation Projects.* Vol. 3. *Palaeo-environment, chronology and features.* Ghent: Academia Press. [SJ]

Crombé, P., Y. Perdaeen, J. Sergant et al. 2002. The Mesolithic-Neolithic transition in the sandy lowlands of Belgium: New evidence. *Antiquity* 76:699–706. [GB]

Deckers, P. H. 1979. The flint material from Swifterbant, Earlier Neolithic of the Northern Netherlands. 1. Sites S-2, S-4, and S-5: Final reports on Swifterbant II. *Palaeohistoria* 21:143–80.

De Roever, J. P. 2004. *Swifterbant-aardewerk: Een analyse van de neolithische nederzettingen bij Swifterbant, 5e millennium voor Christus.* Groningen: University of Groningen.

De Wolf, H., and P. Cleveringa. 2005. *Swifterbant: Nat maar begroeid, wonen in een estuarium.* Utrecht: TNO-NITG.

English, N. B., J. L. Betancourt, J. S. Dean, and J. Quade. 2001. Strontium isotopes reveal distant sources of architectural timber in Chaco Canyon, New Mexico. *Proceedings of the National Academy of Sciences (U.S.A.)* 98:11891–96. [AB]

Evans, L. T. 1993. *Crop evolution, adaptation, and yield.* Cambridge: Cambridge University Press.

Fischer, A. 1982. Trade in Danubian shaft-hole axes and the introduction of the Neolithic in Denmark, *Journal of Danish Archaeology* 1:7–12.

Gehasse, E. F. 1995. Ecologisch-archeologisch onderzoek gevolgd door een overzicht van de bewoningsgeschiedenis van het Neolithicum en de Vroege Bronstijd en de bestaanseconomie in de Noordoostpolder met de nadruk binnen de Holocene delta op vindplaats P14. Ph.D. diss., Amsterdam University.

Hartz, S., D. Heinrich, and H. Lübke. 2002. Coastal farmers: The Neolithisation of northern-most Germany. In *The Neolithisation of Denmark: 150 years of debate*, ed. A. Fischer and K. Kristiansen, 321–40. Sheffield: J. R. Collis. [JI]

Hartz, S., H. Lübke, and T. Terberger. 2007. From fish and seal to sheep and cattle: New research into the process of neolithisation in northern Germany, *Proceedings of the British Academy* 144:565–92.

Hillman, G. 1981. Reconstructing crop husbandry practices from charred remains of crops. In *Farming practice in British prehistory*, ed. R. Mercer, 123–62. Edinburgh: University Press. [PR]

———. 1982. Crop husbandry at the Medieval Farmstead, Cenf Graeanog: Reconstructions from charred remains of plants. *Bulletin of the Board of Celtic Studies* 29:90l–6.

———. 1984. Interpretation of archaeological plant remains: The application of ethnographic models from Turkey. In *Plants and ancient man*, ed. W. A. van Zeist and W. A. Casparie, 1–41. Rotterdam: Balkema. [SJ]

Hillman, G. C., and M. S. Davies. 1999. Domestication rate in wild wheats and barley under primitive cultivation. In *Prehistory of agriculture: New experimental and ethnographic approaches,* ed. P. C. Anderson, 70–102. UCLA Institute of Archaeology Monograph 40.

Hosch, S., and S. Jacomet. 2004 Ackerbau und Sammelwirtschaft: Ergebnisse der Untersuchung von Samen und Früchten. In *Die neolithische Seeufersiedlung Arbon Bleiche 3: Wirtschaft und Umwelt*, ed. S. Jacomet, J. Schibler, and U. Leuzinger, 112–57. Frauenfeld: Amt für Archäologie des Kantons Thurgau. [SJ]

Huisman, D. J., D. C. M. Raemaekers, and A. G. Jongmans. n.d. Investigating Early Neolithic land use in Swifterbant (NL) using micromorphological techniques. MS.

Innes, J. B., J. J. Blackford, and P. J. Davey. 2003. Dating the introduction of cereal cultivation to the British Isles: Early palaeoecological evidence from the Isle of Man. *Journal of Quaternary Science* 18: 603–13. [JI]

Innes, J. B., P. A. Rowley-Conwy, and J. J. Blackford. 2003. The start of the Mesolithic-Neolithic transition in northwest Europe: The palynological contribution. *Antiquity* 77(297). http://www.antiquity.ac.uk. [JI]

Jacomet, S. 2006. Plant economy of the northern alpine lake dwelling area, 3500–2400 BC cal. In *Economic and environmental changes during the 4th and 3rd millennia BC: Proceedings of the 25th Symposium of the AEA, Sept. 2004 in Bad Buchau, Germany*, ed. S. Karg, R. Baumeister, H. Schlichtherle, and D. E. Robinson, 64–83. Environmental Archaeology 11. [SJ]

———. 2007. Neolithic plant economies in the northern alpine foreland from 5500–3500 BC cal. In *The origins and spread of domestic plants in Southwest Asia and Europe*, ed. S. Colledge and J. Conolly, 221–58. Walnut Creek, Calif.: Left Coast Press. [SJ]

———. 2008. Plant economy and village life in Neolithic lake dwellings at the time of the Alpine Iceman. *Vegetation History and Archaeobotany Online.* [SJ]

Jacomet, S., C Brombacher, and M. Dick. 1989. *Archäobotanik am Zürichsee: Ackerbau, Sammelwirtschaft und Umwelt von neolithischen und bronzezeitlichen Seeufersiedlungen im Raum Zürich.* (Ergebnisse von Untersuchungen pflanzlicher Makroreste der Jahre 1979–1988, 7.) Zürich: Orell Füssli Verlag. [SJ]

Joly, C., L. Barillé, M. Barreau, A. Mancheron, and L. Visset. Grain and annulus diameter as criteria for distinguishing pollen grains of cereals from wild grasses. *Review of Paleobotany and Palynology* 146:221–33. [JI]

Jones, G. E. M. 1987. A statistical approach to the archaeological identification of crop processing. *Journal of Archaeological Science* 14:311–23. [SJ]

Jones, G. E. M, M. Charles, A. Bogaard, J. Hodgson, and C. Palmer. 2005. The functional ecology of present-day arable weed floras and its applicability for the identification of past crop husbandry. *Vegetation History and Archaeobotany* 14:493–504. [SJ]

Jones, G., and P. Rowley-Conwy. 2007. On the importance of cereal cultivation in the British Neolithic. In *The origins and spread of domestic plants in Southwest Asia and Europe*, ed. S. Colledge and J. Conolly, 391–419. Walnut Creek, Calif.: Left Coast Press. [PR]

Kalis, A. J., J. Merkt, and J. Wunderlich. 2003. Environmental changes during the Holocene climatic optimum in central Europe: Human impact and natural causes. *Quaternary Science Reviews* 22:33–79. [AB]

Korsmo, E. 1954. *Urgas i nåtidens jordbruk.* Oslo: A~S Norsk Landbruks Forlag.

Kreuz, A. 2007. Archaeobotanical perspectives on the beginning of agriculture north of the Alps. In *The origin and spread of domestic plants in Southwest Asia and Europe*, ed. S. Colledge and J. Conolly, 259–94. Walnut Creek, Calif.: Left Coast Press. [AB]

Kubiak-Martens, L. 2002. New evidence for the use of root in pre-agrarian subsistence recovered from the last Mesolithic site at Halsskov, Danmark. *Vegetation History and Archaeobotany* 11:23–31. [SJ]

———. 2006. Botanical remains and plant food subsistence. In *Schipluiden: A Neolithic settlement on the Dutch North Sea coast c. 3500 cal BC,* ed. L. P. Louwe Kooijmans and P. F. B. Jongste, 317–38. Analecta Praehistorica Leidensia 317–38.

Küster, H.-J. 2000. The history and culture of food and drink in Europe: Northern Europe—Germany and surrounding regions. In *The Cambridge world history of food,* ed. K. F. Kiple and K. C. Ornelas, 1226–32. Cambridge: Cambridge University Press.

Lang, A. 2003. Phases of soil erosion-derived colluviation in the loess hills of south Germany. *Catena* 51:209–21. [AB]

Louwe Kooijmans, L. P. 1974. *The Rhine/Meuse Delta: Four studies on its prehistoric occupation and Holocene geology.* Oudheidkundige Mededelingen uit het Rijksmuseum van Oudheden te Leiden 52–54/Analecta Praehistorica Leidensia 7.

———. 1976. Local development in a borderland. A survey of the Neolithic at the Lower Rhine. *Oudheidkundige Mededelingen uit het Rijksmuseum van Oudheden te Leiden* 57: 227–97.

———. 1987. Neolithic settlement and subsistence in the wetlands of the Rhine/Meuse Delta in the Netherlands. In *European wetlands in prehistory,* ed. J. M. Coles and A. J. Lawson, 227–51. Oxford: Oxford University Press.

———. 1993. Wetland exploitation and upland relations of prehistoric communities in the Netherlands. In *Flatlands and wetlands: Current themes in East Anglian archaeology,* ed. J. Gardiner, 71–116. Norwich: Center of East English Studies.

———. 2001. Synthese. In *Hardinxveld-De Bruin: Een kampplaats uit het Laat-Mesolithicum en het begin van de Swifterbant-cultuur (5500–4450 v. Chr.)*, ed. L. P. Louwe Kooijmans, 499–528. Rapportages Archeologische Monumentenzorg 88.

———. 2003. The Hardinxveld sites in the Rhine/Meuse delta, the Netherlands 5500–4500 cal BC. In *Mesolithic on the move: Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000,* ed. L. Larsson, H. Kindgren, K. Knutson, D. Loeffler, and A. Åkerlund, 608–24. Oxford: Oxbow Books. [MCL]

———. 2005. Hunters become farmers: Early Neolithic B and Middle Neolithic A. In *The prehistory of the Netherlands,* ed. L. P. Louwe Kooijmans, P. W. van der Broeke, H. Fokkens, and A. L. van Gijn, 249–71. Amsterdam: Amsterdam University Press.

———. 2007. The gradual transition to farming in the Lower Rhine Basin. In *Going over: The Mesolithic-Neolithic transition in north-west Europe*, ed. A. Whittle and V. Cummings, 287–309. Proceeding of the British Academy 144. [AB]

Mason, S. L. R., and J. G. Hather, eds. 2002. *Hunter-gatherer archaeobotany: Perspectives from the northern temperate zone.* London: Institute of Archaeology, University College London. [SJ]

Nesbitt, M. 2002. When and where did domesticated cereals first occur in southwest Asia?. In *The dawn of farming in the Near East,* ed. R. T. J. Cappers and S. Bottema, 113–32. Berlin: Ex Oriente.

Out, W. A. 2008. Neolithisation at the site Brandwijk-Kerhof, the Netherlands: Natural vegetation, human impact, and plant food subsistence. *Vegetation History and Archaeobotany* 17:25–39. [MCL]

Perry, D. 2002. Preliminary results of an archaeobotanical analysis of Mesolithic sites in the Veenkolonien, Province of Groningen, the Netherlands. In *Hunter-gatherer archaeobotany: Perspectives from the northern temperate zone*, ed. S. L. R. Mason and J. G. Hather, 108–16. London: Institute of Archaeology, University College London. [SJ]

Peters, F. J. C., and J. H. M. Peeters, eds. 2001. *De opgraving van de mesolithische en neolithische vindplaats Urk-E4 (Domineesweg, gemeente Urk)*. Rapportage Archeologische Monumentenzorg 93.

Prescott, C. 1995. *From Stone Age to Iron Age: A study from Sogn, western Norway.* British Archaeological Reports International Series 603. [PR]

Price, D. T. 1996. The first farmers in southern Scandinavia. In *The origins and spread of agriculture and pastoralism in Eurasia*, ed. D. R. Harris, 346–62. London: UCL Press. [SJ]

Raemaekers, D. C. M. 1997. The history of the Ertebølle parallel in Dutch Neolithic studies and the curse of the point-based pottery. *Archaeological Dialogues* 4:220–34.

———. 1999. *The articulation of a "New Neolithic": The meaning of the Swifterbant culture for the process of Neolithisation in the western part of the North European Plain.* Leiden: Leiden University.

———. 2003. Cutting a long story short? The process of neolithization in the Dutch delta re-examined. *Antiquity* 77:780–89.

Raemaekers, D. C. M., C. C Bakels, B. Beerenhout, A. L. van Gijn, K. Hänninen, K. Molenaar, D. Paalman, M. Verbruggen, and C. Vermeeren. 1997. Wateringen 4: A settlement of the Middle Neolithic Hazendonk 3 Group in the Dutch coastal area. *Analecta Praehistorica Leidensia* 29: 143–92. [SJ]

Robinson, D. E. 2003. Neolithic and Bronze Age agriculture in southern Scandinavia: Recent archaeobotanical evidence from Denmark. *Environmental Archaeology* 8:145–65. [SJ, PR]

Robinson, D. E., and J. A. Harild. 2002 Archaeobotany of an early Ertebölle (late Mesolithic) site at Halsskov, Zealand, Denmark. In *Hunter-gatherer archaeobotany: Perspectives from the northern temperate zone*, ed. S. L. R. Mason and J. G. Hather, 84–95. London: UCL Institute of Archaeology. [SJ]

Rösch, M. 2000. Anthropogener Landschaftswandel in Mitteleuropa während des Neolithikums. *Germania* 78: 293–318. [AB]

Rösch, M., O. Ehrmann, L. Herrmann, E. Schulz, A. Bogenrieder, J. P. Goldammer, M. Hall, H. Page, and W. Schier. 2002. An experimental approach to Neolithic shifting cultivation. *Vegetation History and Archaeobotany* 11:143–54. [SJ]

Schaminée, J. H. J., E. J. Weeda, and V. Westhoff. 1998. *De vegetatie van Nederland.* Vol. 4. *Plantengemeenschappen van de kust en van binnenlandse pioniermilieus.* Leiden: Opulus Press.

Sherratt, A. 1980. Water, soil, and seasonality in early cereal cultivation. *World Archaeology* 2:313–30. [AB]

Tinner, W., E. H. Nielsen, and A. F. Lotter. 2007. Mesolithic agriculture in Switzerland? A critical review of the evidence. *Quaternary Science Reviews* 26:1416–31. [JI]

Van Gijn, A. L., and L. P. Louwe Kooijmans. 2005. Early and Middle Neolithic: Introduction. In *The prehistory of the Netherlands,* ed. L. P. Louwe Kooijmans, P. W. van den Broeke, H. Fokkens, and A. L. van Gijn, 203–18. Amsterdam: Amsterdam University Press.

van Haaster, H. 2001. *Archaeobotanisch onderzoek naar de neolithische bewoning op de vindplats Rijswijk-Ypenburg.* Biaxiaal 188. [SJ]

Van Zeist, W., and R. M. Palfenier-Vegter. 1981. Seeds and fruits from the Swifterbant S3 site: Final reports on Swifterbant IV. *Palaeohistoria* 23:105–68.

Van Zeist, W., T. C. Van Hoorn, and S. Bottema, and H. Woldring. 1976. An agricultural experiment in the unprotected salt marsh.. *Palaeohistoria* 18:111–53.

Vernimmen, T. 2001. "Macroresten,"*De opgraving van de mesolithische en neolothische vindplaats Urk-E4 (Domineesweg, gemeente Urk).* ed. F. J. C. Peters and J. H. M. Peeters, 60–70. Rapportages Archeologische Monumentenzorg 93.

Weeda. E. J., R. Westra, C. Westra, and T. Westra. 1994. *Nederlandse oecologische flora: Wilde Planten en hun relaties 5.* Amsterdam: IVN.

Willerding, U. 1991. Präsenz, Erhaltung und Repräsentanz von Pflanzenresten in archäologischen Fundgut. In *Progress in Old World palaeoethnobotany*, ed. W. A. van Zeist, K. Wasylikowa, and K.-E. Behre, 25–51. Rotterdam: Balkema. [SJ]

Wunderlich, J. 2000. Prähistorische und historische Bodenerosion im Amöneburger Becken: Abgeleitet aus einer Sequenz datierter Kolluvien. *Berichte der Kommission für Archäologische Landesforschung in Hessen* 5:9–15. [AB]

Zeiler, J. T. 1997. *Hunting, fowling, and stock-breeding at Neolithic sites in the Western and Central Netherlands.* Groningen: Archaeobone.

Zvelebil, M. 1986. Mesolithic societies and the transition to farming: Problems of time, scale, and organization. In *Hunters in transition. New directions in archaeology*, ed. M. Zvelebil. Cambridge: Cambridge University Press. [SJ]

———. 1998. Agricultural frontiers, Neolithic origins, and the transition to farming in the Baltic Basin. In *Harvesting the sea, farming the forest*, ed. M. Zvelebil, L. Domanska, and R. Dennell, 9–28. Sheffield: Sheffield Academic Press. [SJ]